

What is claimed is:

1. A system for thermal protection, the system comprising:

a cap, having at least one exposed surface and a cap interface surface spaced apart from the cap exposed surface, the cap having at least one polygonal or curvilinear depression and one or more bosses at the cap interface surface, each boss having at least one buttress thread or keyway in the cap, the cap having a material composition including carbon and silicon and having at least first and second spaced apart depressions in a cap interface surface;

an insulator base having an insulator base interface surface including at least one polygonal or curvilinear projections, which mates with the respective at least one depression in the cap interface surface and which compensates for a difference in thermal expansion between the cap and the insulator base at the insulator base interface surface, the insulator base having an insulator base second surface spaced apart from the insulator base interface surface, and having at least one insulator base aperture that extends from the insulator base interface surface to the insulator base second surface, the insulator base having a material composition including alumina and including at least one of silica, boron or other refractory material; and

a transition region, positioned between, and contiguous to, the cap interface surface and the insulator base interface surface, having a thickness of about 1.2 mm or more, having a material composition comprising glass, a selected polymer and a selected mixture of  $\text{TaSi}_2$ ,  $\text{MoSi}_2$  and  $\text{WSi}_2$ , and having at least one transition region aperture at a location corresponding to the at least one insulator base aperture; and

at least one pin that extends through the at least one insulator base aperture and through the at least one transition region aperture, that has a plate or key at a

first pin end that is received in the at least one threaded buttress or keyway, that is bonded to the cap at the first pin end, and that is bonded to the insulator base second surface at a second pin end, the pin having a material composition that is substantially the same as the material composition of the insulator base bulk component.

2. The system of claim 1, wherein said material composition of said cap is chosen to withstand temperatures up to or above 3000 °F over a selected time interval.

3. The system of claim 1, wherein said material composition of said cap is chosen to withstand temperatures up to or above 3600 °F over a selected time interval.

4. The system of claim 1, further comprising a cap surface layer positioned at said cap exposed surface of said cap, having a surface layer thickness in a selected range of about 1 – 2.5 mm, and having a material composition comprising a first selected fraction of tantalum disilicide, a second selected fraction of molybdenum disilicide, a third selected fraction of tungsten disilicide and a fourth selected fraction of glass, wherein the cap surface layer is subjected to a HETC treatment.

5. The system of claim 4, wherein said cap surface layer is provided as a functionally gradient layer.

6. The system of claim 4, wherein said first fraction, said second fraction and said fourth fraction have respective ranges 5-70 percent, 0-30 percent and 10-95 percent.

7. The system of claim 6, wherein said cap material is primarily ROCCI.

8. The system of claim 4, wherein said glass in said cap coating material is primarily borosilicate glass.

9. The system of claim 1, wherein said cap material is primarily silicon carbide.

10. The system of claim 1, wherein said cap material is primarily silicon-oxy-carbide.

11. The system of claim 1, further comprising an insulator base surface layer, positioned at said insulator base interface surface, having a surface layer thickness in a selected range 1 – 2.5 mm, and having a material composition comprising a fifth selected fraction of tantalum disilicide, a sixth selected fraction of molybdenum disilicide, a seventh selected fraction of tungsten disilicide and an eighth selected fraction of glass, wherein the insulator base surface layer is subjected to a HETC treatment.

12. The system of claim 11, wherein said insulator base surface layer is provided as a functionally gradient layer.

13. The system of claim 11, wherein said fifth fraction, said sixth fraction and said eighth selected fractions have respective ranges 5-70 percent, 0-30 percent and 10-95 percent.

14. The system of claim 11, wherein said glass in said insulator base coating material is primarily borosilicate glass.

15. The system of claim 1, wherein said insulator base material is primarily TUF1.

16. A system for thermal protection, comprising at least a surface cap and an insulator base connected together mechanically and by ceramic bonding, where each of the cap and insulator base has a different material composition, experiences a different range of temperatures, and has a different thermal expansion, and where the cap and insulator base are held together by compensating for the different thermal expansions.

17. The system of claim 16, wherein said cap and said insulator base are connected across a common interface, a portion of said cap and a portion of said insulator base adjacent to the interface having a depression and a projection, respectively, that mate with each other to compensate for different thermal expansions of said cap and said insulator base, further comprising:

a pin, bonded at a first pin end to said cap adjacent to the interface, extending through said insulator base, and bonded at a second pin end to a second surface of said insulator base that is spaced apart from the interface.

18. The system of claim 17, wherein said pin has a plate at said first pin end that is received in at least one threaded buttress or keyway in said cap, that is bonded to said cap at said first pin end, and that is bonded to said insulator base second surface at said second pin end, said pin having a material composition that is substantially the same as a material composition of said insulator base bulk component.

19. The system of claim 16, wherein said temperature range of said cap extends up to between 3000 °F and 3600 °F and said temperature range of said insulator base extends down to about 400 °F.

20. The system of claim 16, wherein said cap material is primarily ROCCI.

21. The system of claim 16, wherein said cap material is primarily silicon carbide.

22. The system of claim 16, wherein said cap material is primarily silicon-oxy-carbide.

23. The system of claim 16, wherein said insulator base material is primarily TUF1.